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Economic Analysis of Stationary PEM Fuel Cell Systems

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This presentation does not contain any proprietary or confidential information

Team

Battelle Memorial Institute is the Prime Contractor

- **Darrell Paul, Project Manager, Battelle -- Columbus**
- **Harry Stone, Economist and Principal Investigator, Battelle – Cincinnati**
- **Steve Millett, Futurist, Battelle – Columbus**
- **Gretchen Hund, Stakeholder Involvement, Battelle – Seattle**
- **Kathya Mahadevan, Technical and Market Analyst, Battelle – Columbus**

Input from PEM fuel cell stakeholders is critical to the success of the program.

Subcontractors will be used on an as-needed basis and per DOE's direction.

Objectives

To develop an understanding of the economic, technology, and marketplace drivers needed for commercialization of stationary PEM fuel cell systems out to the year 2015.

The action plan will:

- **Evaluate high potential stationary PEMFC applications;**
- **Identify critical success factors required for commercialization;**
- **Develop a technical targets table for each application (cost, reliability, size, response, emissions, electric load versus time, etc.); and**
- **Educate stakeholders and raise awareness of national programs.**

Benefits

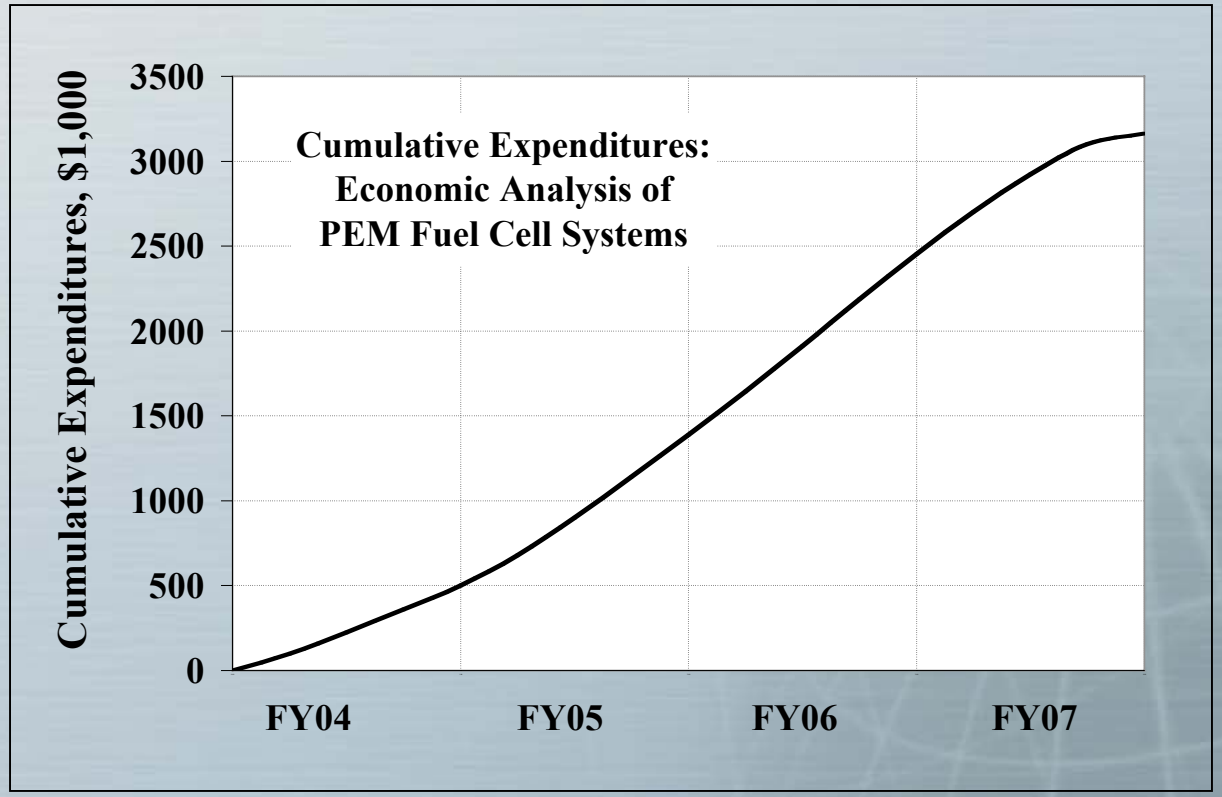
- Identifies factors likely to provide leverage in PEM fuel cell commercialization over the next 10 years.
- Informs policy and investment strategies to the benefit of government and private industry interests.
- Identifies potential points for public/private cooperation and consensus.
- Establishes realistic expectations: What will have to happen to reach these targets?

Budget

Since this is not a technology development project, there is no contractor cofunding. All funds are DOE's.

FY	$Total
FY 04	500,000
FY 05	887,933
FY 06	1,065,520
FY 07	710,347
Total	3,163,800

Qtr	$ Total
1	250,000
2	190,000
3	60,000



DOE Technical Barriers for Stationary PEM FC

(These are explained in DOE's Hydrogen, Fuel Cell, and Infrastructure Technologies Multi-Year Research, Development and Demonstration Plan: Planned activities for 2003-2010)

Transportation Barriers A,B,C, and D do not apply.

Distributed Generation Systems Barriers:

- E. Durability
- F. Heat Utilization
- G. Power Electronics
- H. Startup Time

Fuel-Flexible Fuel Processor Barriers:

- I. Fuel Proc. Startup/Transient
- J. Durability
- K. Emissions/Environment
- L. H_2 Quality / CO Cleanup
- M. Fuel Proc. Sys Integration/Efficiency
- N. Cost

Fuel Cell Component Barriers:

- O. Stack Mat. & Manf. Cost
- P. Durability
- Q. Electrode Performance
- R. Thermal & Water Manage

DOE Technical Targets For Stationary Fuel Cell Systems in 2010 (Also from DOE's Multiyear Plan)

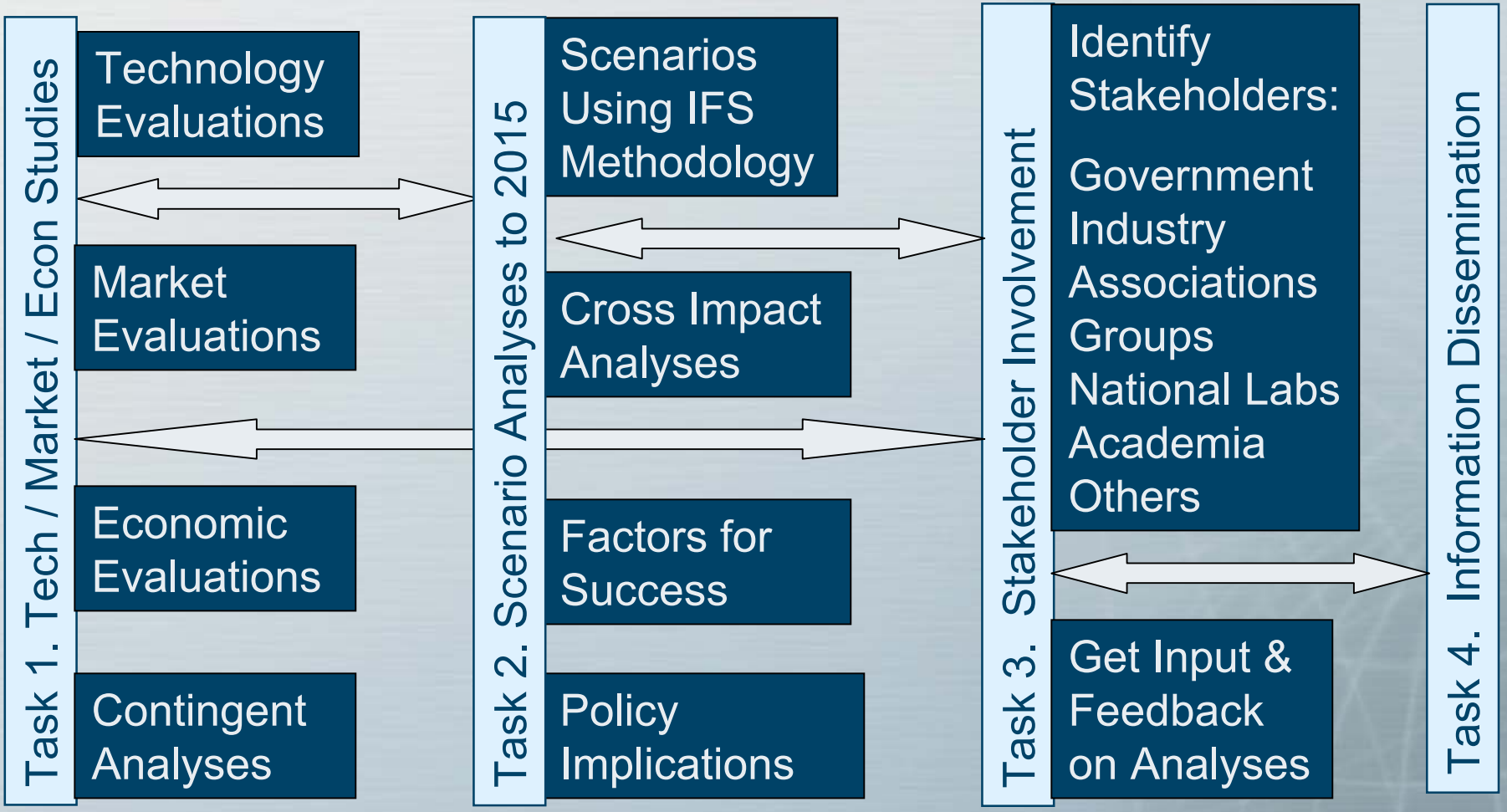
The first number listed is for small (3-25 kW) PEMFC systems and the second number is for large (50-250kW); single numbers are for both systems.

- **$1000 / $750 Cost per kW**
- **35 / 40% Elec. Efficiency**
- **80% CHP Efficiency**
- **< 3 msec Transient Response**

- **40,000 hours Durability**
- **5 / 10 Min. Cold Startup**
- **-35 to +40 C Survivability**
- **65 / 55 dba Noise @ 1 m**

- **< 9 / 1.5 g/1000kWh combined NO_x, CO, SO_x, hydrocarbon, and particulate emissions.**

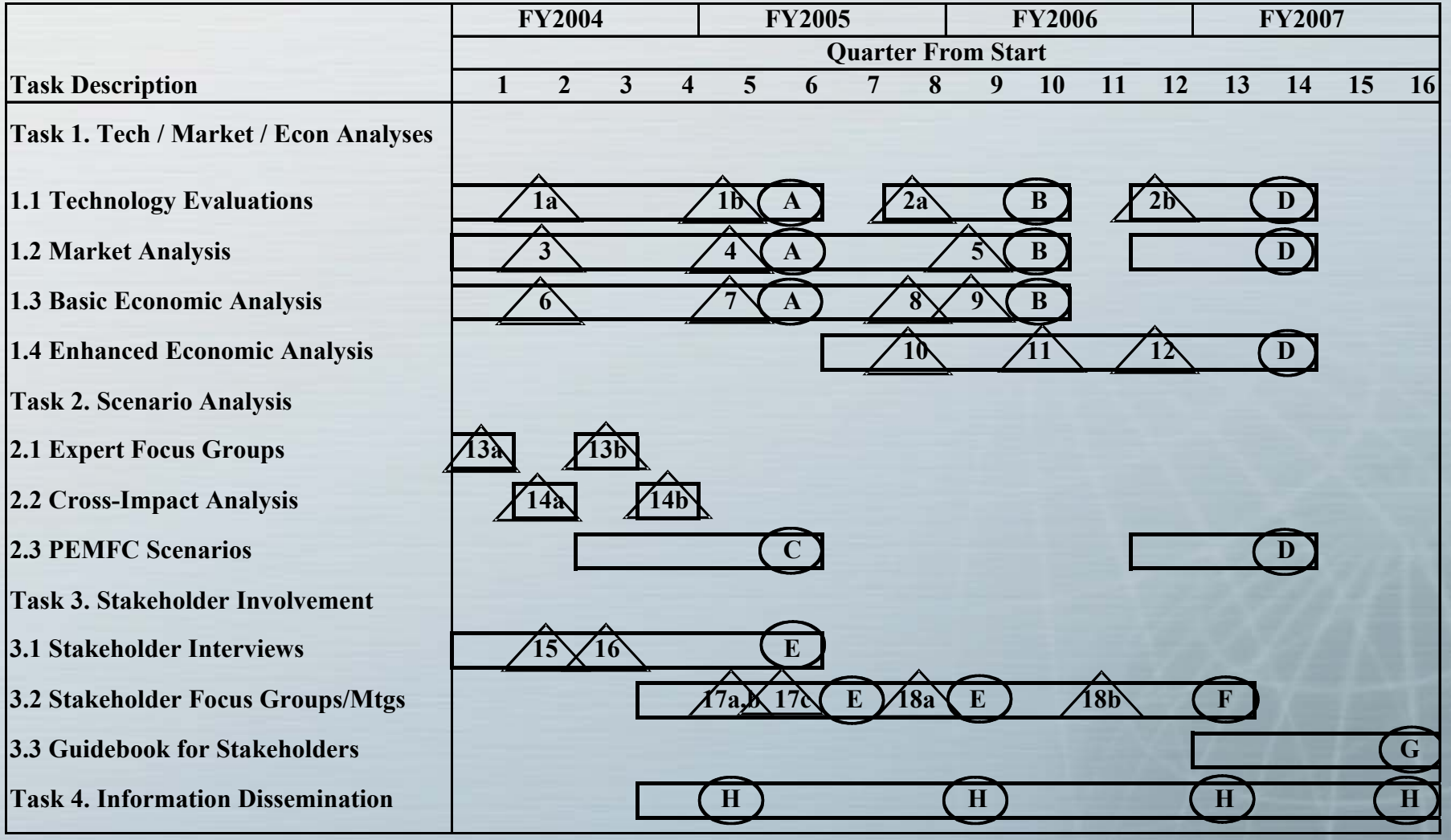
Approach


Task 1. Tech / Market / Econ Studies
Technology Evaluations
Market Evaluations
Economic Evaluations
Contingent Analyses
Task 2. Scenario Analyses to 2015
Scenarios Using IFS Methodology
Cross Impact Analyses
Factors for Success
Policy Implications
Task 3. Stakeholder Involvement
Identify Stakeholders:
Government
Industry
Associations
Groups
National Labs
Academia
Others
Get Input & Feedback on Analyses
Task 4. Information Dissemination

Project Safety

- Safety (and perceived safety) is a barrier to fuel cell commercialization.
- Safety codes and standards regulating the storage and use of H_2 is a barrier to fuel cell commercialization.

Schedule (milestones and deliverables next viewgraph)



Milestones and Deliverables

Milestones	Deliverables
Task 1. Tech / Market / Econ Analyses	
1(a,b). Expert focus groups for technology ratings	**A. Interim report on econ/tech/market analyses**
2(a,b). Annual update of technology ratings	**B. Updated interim report**
3. Identify and segment markets	
4. Identify highest potential opportunities	
5. Impact of financial incentives and special programs	
6. Cost targets for 2005, 2010, 2015	
7(a,b). Impacts of restructuring & oil dependency	
8. Government policy impacts	
9. Critical success factors and barriers	
10. Environmental Assessment	
11. Value policy incentives and disincentives	
12. Contingent analyses	

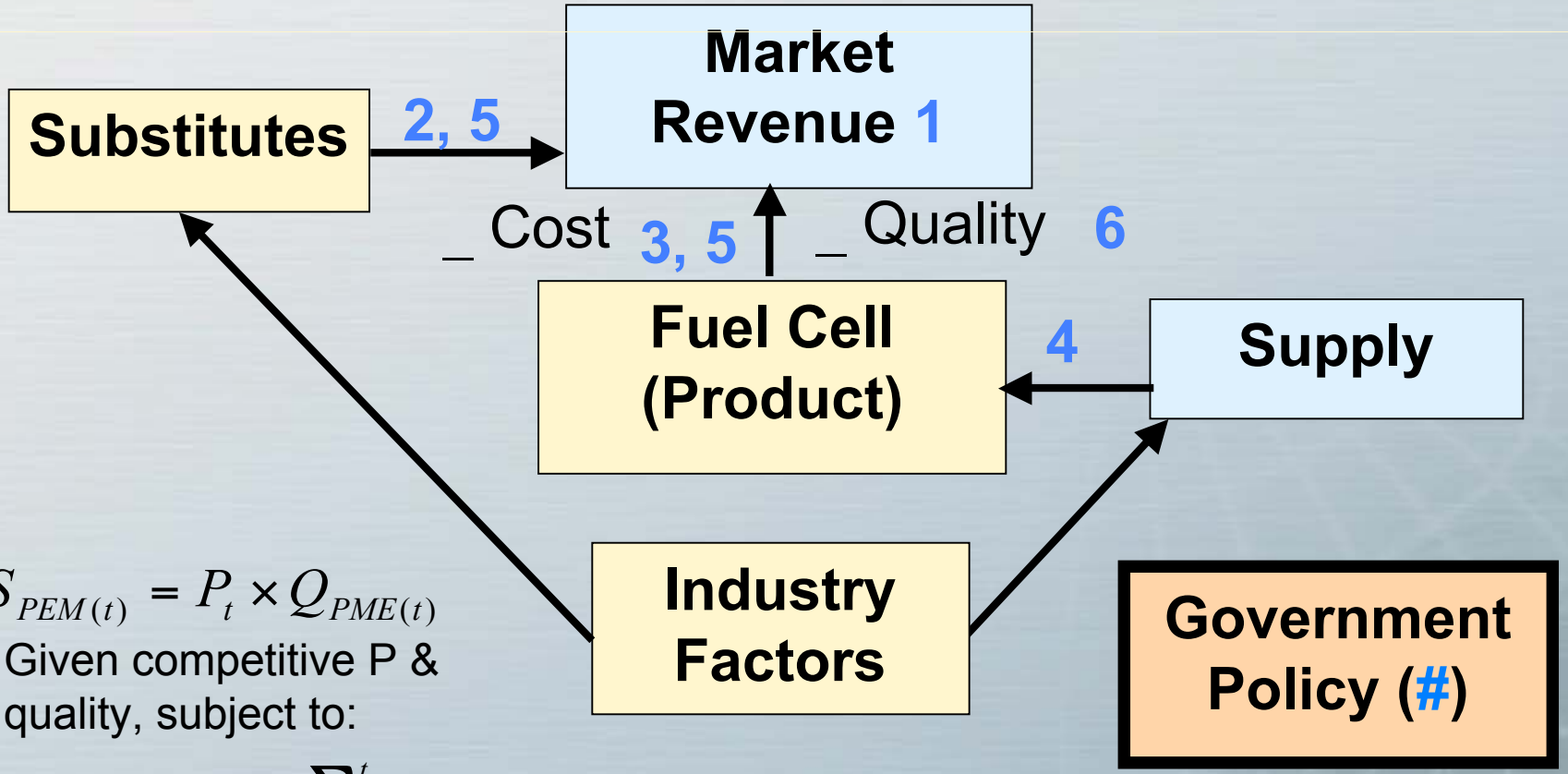
Milestones and Deliverables

Milestones	Deliverables
Task 2. Scenario Analyses	
13(a,b). Expert focus groups to define descriptors	C. Report on PEMFC scenarios
14(a,b). Cross-Impact analyses of descriptors	D. PEM Fuel Cell Vision 2015 Report
Task 3. Stakeholder Involvement	E. Letter report of interview or meeting results
15. Stakeholder involvement plan and list	F. Stakeholder feedback report
16. Develop interview protocol	G. Guidebook
17(a,b,c). Focus groups	
18(a,b). Stakeholder Partnership Team (SPT) meeting	
Task 4. Information Dissemination	H. Seminar presentations

Technical Accomplishments/Progress

- Developed integrated evaluative approach.
- Completed two expert focus groups to provide input on descriptors for the Interactive Future Simulations model.
- Currently surveying fuel cell developers, users, and competitors in the back-up power marketplace.
- Evaluating non-technical factors, like industry factors and policy issues, that will affect the commercialization of back-up power marketplace.

Technical Accomplishments: Draft Integrated Model: Markets, Economics, and Policy Impacts PEM Fuel Cells for Stationary Applications



$$S_{PEM(t)} = P_t \times Q_{PME(t)}$$

Given competitive P & quality, subject to:

$$Q_{PEM} = (Q_{tot(t)} \times \sum_0^t (R_{PEM(n)}) \times f(Q_{tot(t)}, C_{R\&D}, I_t)$$

$$R_{PEM} = f(K, C_s, b, d, m, r)$$

Technical Approach - Scenario Analysis Methodology Battelle

Topic Question

Expert Focus Groups (3)

Identify Issues

Descriptors (18-24)

Cross-Impact Matrix

- Trend Analysis
- White Papers

refinements, iterations & simulations

Most Likely Scenarios

Robust Strategies

Policy Decisions

Technical Accomplishment: Scenario Analysis

Topic Question: What will be the most likely markets and economic impacts of stationary PEM fuel cells in the range of 1kW to 250 kW in the U.S. by the year 2015?

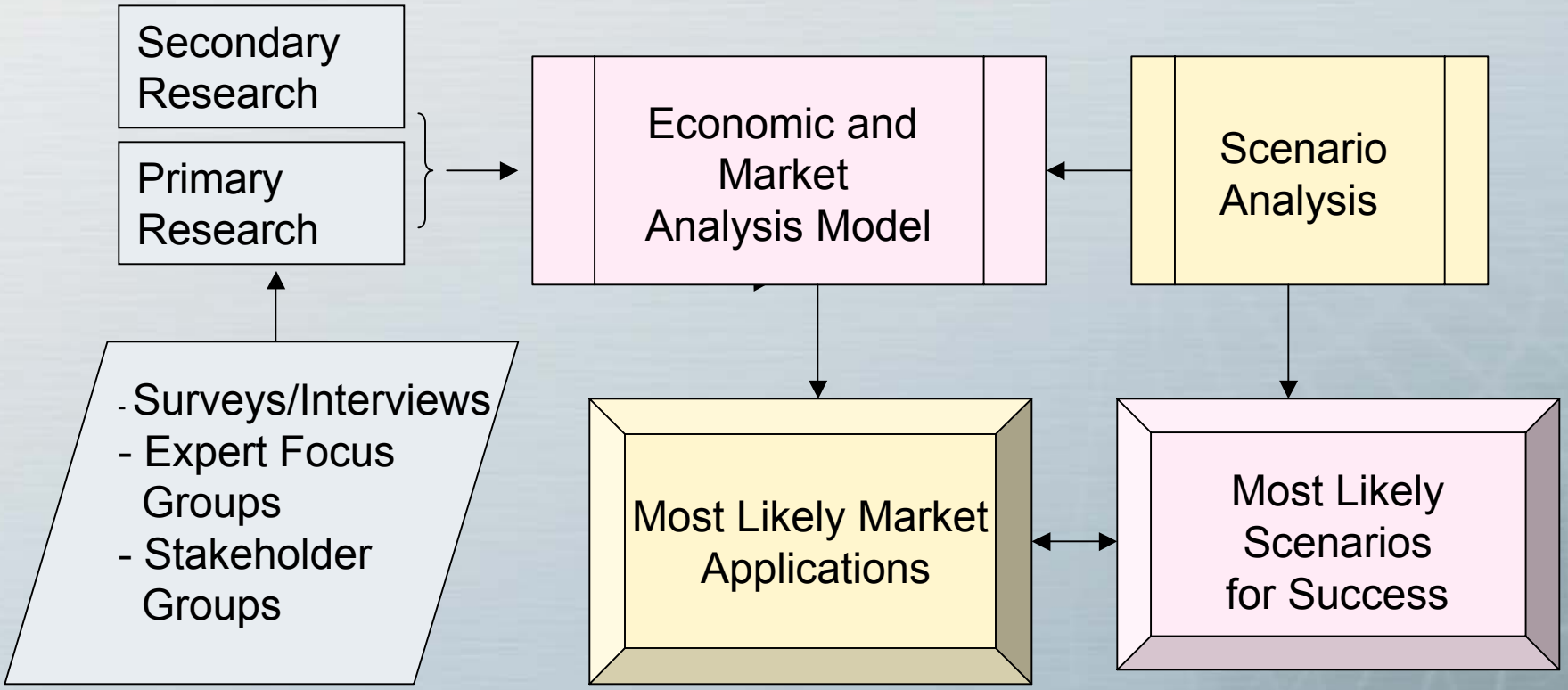
- Focus group 1 (December 12, 2003 in Columbus, Ohio): 16 participants representing the Ohio Fuel Cell Coalition, NASA Glenn Research Center, FirstEnergy, GrafTech, Johnson Matthey Fuel Cells, The Ohio State University, EWI, Cinergy, Ohio Department of Development, American Electric Power, Case Western Reserve University, and Battelle.
- Identified and rank-ordered 65 potential drivers impacting the market for stationary PEM fuel cells in the U.S. to the year 2015.

Technical Accomplishments: Scenario Analysis

Scenario Analysis 2 (May 12, 2004 in Washington D.C.)

- Value of PEM Fuel Cell to Customers
- Cost of PEM Fuel Cells
- PEM Fuel Cell Investments
- PEM Fuel Cell Manufacturing
- PEM Fuel Cell Stack Technical Advances
- Hydrogen Availability
- Fossil Fuel Technological Improvements
- Energy Storage Technologies
- Environmental Regulations and Standards
- Public Policy Support for PEM Fuel Cells
- National Energy Policy and Security
- Electrical Grid Sufficiency and Reliability
- Cogeneration, Backup Power, and DG Options
- Grid Electricity Prices
- Prices of Fuels for PEM Fuel Cells
- Fuel Cell Commercialization Leadership
- PEM Fuel Cell Stationary Power Units in Japan and Europe
- PEM Fuel Cells in Automotive Applications
- PEM Fuel Cell Applications and Markets
- Economic Impact of PEM Fuel Cells

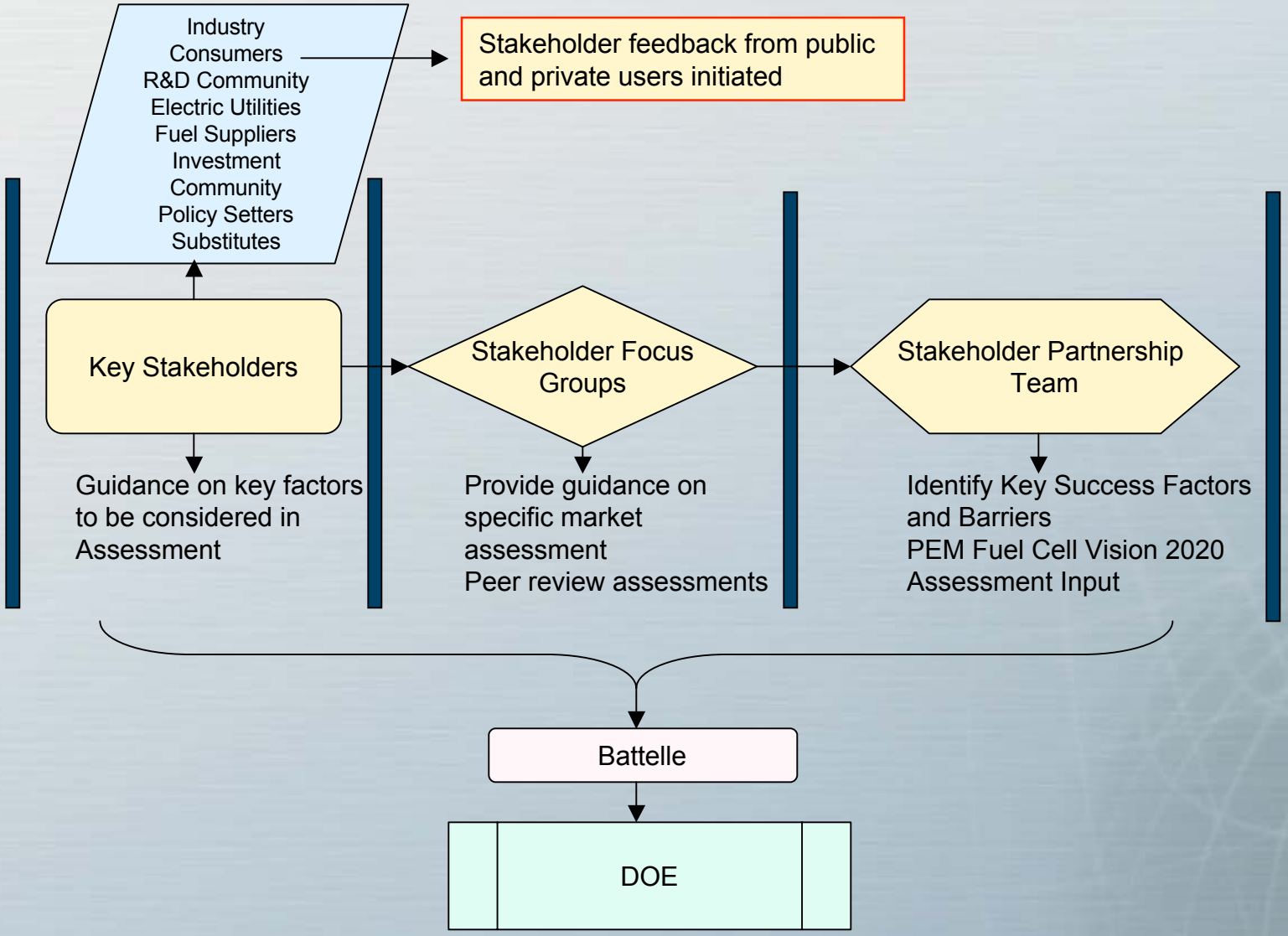
Backup Power Market Analysis Model



Technical Accomplishments: Market Analysis for Back-up Power Markets

- Secured and reviewed economics reports on distributed energy/PEM fuel cell markets.
- Determined types of primary data required.
- Completed development of survey instruments.
- Completed initial identification and characterization of major market segments.
- Competing technology information obtained including UPS systems, battery technologies, microturbines, generators, photovoltaics and wind power.
- Industry factors determined through secondary research, interviews with industry experts, and scenario analysis focus groups.
- Benchmarking of PEM FC technology for back-up power markets initiated.

Interactions and Collaboration



Stakeholder Feedback from Public and Private Consumers on Critical Commercialization Factors

16 surveys or in-depth interviews completed (April 23). Some key themes are:

- Cost is the most significant barrier *in most cases;*
- Reliability a must;
- Durability critical and not adequate; and
- Hydrogen storage / reformation an issue.

Selected Comments:

- Clean green and reduced emissions important to their customers. (Starwood Hotels)
- "Having higher reliability than my competitors has given me new customers!" (Nat. Bank Omaha)
- "What better place to demonstrate the latest in clean technology, given we have 3 million visitors/year" (Yellowstone National Park)

Future Work

- Complete scenario analysis Fall 2004.
- Select / evaluate additional market segment.
- Begin work on additional technology assessment.
- Begin enhanced economic analysis (e.g., contingent valuation).
- Initiate stakeholder focus-group and hold meetings.
- Update technology and market data.